Prevalence of Obesity, Diabetes, and Obesity-Related Health Risk Factors, 2001

Ali H. Mokdad, PhD
Earl S. Ford, MD, MPH
Barbara A. Bowman, PhD
William H. Dietz, MD, PhD
Frank Vinicor, MD, MPH
Virginia S. Bales, MPH
James S. Marks, MD, MPH

Context Obesity and diabetes are increasing in the United States.

Objective To estimate the prevalence of obesity and diabetes among US adults in 2001.

Design, Setting, and Participants Random-digit telephone survey of 195 005 adults aged 18 years or older residing in all states participating in the Behavioral Risk Factor Surveillance System in 2001.

Main Outcome Measures Body mass index,based on self-reported weight and height and self-reported diabetes.

Results In 2001 the prevalence of obesity (BMI ≥30) was 20.9% vs 19.8% in 2000, an increase of 5.6%. The prevalence of diabetes increased to 7.9% vs 7.3% in 2000, an increase of 8.2%. The prevalence of BMI of 40 or higher in 2001 was 2.3%. Overweight and obesity were significantly associated with diabetes, high blood pressure, high cholesterol, asthma, arthritis, and poor health status. Compared with adults with normal weight, adults with a BMI of 40 or higher had an odds ratio (OR) of 7.37 (95% confidence interval [CI], 6.39-8.50) for diagnosed diabetes, 6.38 (95% CI, 5.67-7.17) for high blood pressure, 1.88 (95% CI,1.67-2.13) for high cholesterol levels, 2.72 (95% CI, 2.38-3.12) for asthma, 4.41 (95% CI, 3.91-4.97) for arthritis, and 4.19 (95% CI, 3.68-4.76) for fair or poor health.

Conclusions Increases in obesity and diabetes among US adults continue in both sexes, all ages, all races, all educational levels, and all smoking levels. Obesity is strongly associated with several major health risk factors.

JAMA. 2003;289:76-79 www.jama.com

OBESITY AND DIABETES ARE major causes of morbidity and mortality in the United States.[1-3] Evidence from several studies indicates that obesity and weight gain are associated with an increased risk of diabetes[4,5] and that intentional weight loss reduces the risk that overweight people will develop diabetes.[6] Each year, an estimated 300 000 US adults die of causes related to obesity,[7] and diabetes is the sixth leading cause of death.[3] Correspondingly, both obesity and diabetes generate immense health care costs.[8,9]

We recently reported that the prevalence of obesity and diabetes among US adults increased substantially from 1990 to 2000.[10] We used data from the 2001 Behavioral Risk Factor Surveillance System (BRFSS) to examine whether these increases are continuing. In addition, we examined the association between obesity and several other important health risk factors, as well as self-rated general health.

METHODS

The BRFSS is a cross-sectional telephone survey conducted by the Centers for Disease Control and Prevention and state health departments. The BRFSS questionnaire consists primarily of questions about personal behaviors that increase risk for 1 or more of the 10 leading causes of death in the United States. The BRFSS uses a multistage cluster design based on random-digit dialing to select a representative sample from each state's noninstitutionalized civilian residents aged 18 years or older. Data from each state are pooled to produce nationally representative estimates. A detailed description of the survey methods is available elsewhere.[11,12]

The 2001 BRFSS included questions on health status, health care access, exercise, hypertension awareness, cholesterol awareness, asthma, diabetes, arthritis, immunization, tobacco use, alcohol consumption, firearms, disability, physical activity, prostate cancer screening, colorectal cancer screening, and human immunodeficiency virus or acquired immunodeficiency syndrome (all BRFSS questionnaires from 1991 to 2002 are available at http://www.cdc.gov/brfss).

We used data on self-reported weight and height to calculate body mass index (BMI), calculated as weight in kilograms divided by the square of height in meters. Participants were classified as overweight (class 1) if their BMI ranged from 25 through 29.9. We further divided obesity (BMI ≥30) into 2 levels to analyze the association between BMI groups and medical conditions: BMI of 30 through 39.9, class 2; BMI of 40 or

Author Affiliations: Divisions of Adult and Community Health (Drs Mokdad and Ford and Ms Bales), Nutrition and Physical Activity (Dr Dietz), and Diabetes Translation (Drs Bowman and Vinicor), Office of the Director (Dr Marks), National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Ga.
Corresponding Author and Reprints: Ali H. Mokdad, PhD, Division of Adult and Community Health, 4770 Buford Hwy NE, Mailstop K66, Atlanta, GA 30341-3717 (e-mail: ahm1@cdc.gov).

Table 1. Obesity and Diabetes Prevalence Among US Adults by Selected Characteristics, Behavioral Risk Factor Surveillance System, 2001*

	Obesity, % (SE)	Diabetes, % (SE)
Total	20.9 (0.16)	7.9 (0.11)
Sex		
Men	21.0 (0.24)	6.8 (0.14)
Women	20.8 (0.21)	8.9 (0.15)
Age, y		
18-29	14.0 (0.32)	2.1 (0.12)
30-39	20.5 (0.36)	4.1 (0.16)
40-49	24.7 (0.39)	6.6 (0.27)
50-59	26.1 (0.42)	11.2 (0.31)
60-69	25.3 (0.51)	15.1 (0.41)
≥70	17.1 (0.39)	15.5 (0.36)
Race		
White	19.6 (0.16)	7.2 (0.10)
Black	31.1 (0.59)	11.2 (0.39)
Hispanic	23.7 (0.73)	9.0 (0.45)
Other	15.7 (0.63)	8.2 (0.59)
Education		
<High school	27.4 (0.59)	13.0 (0.40)
High school	23.2 (0.29)	8.2 (0.18)
Some college	21.0 (0.30)	7.5 (0.20)
>College	15.7 (0.24)	5.5 (0.18)
Smoking status		
Never	20.9 (0.23)	7.1 (0.15)
Ex-smoker	23.9 (0.33)	11.1 (0.24)
Current	17.8 (0.31)	6.1 (0.18)

*Data reflect national estimates.

higher, class 3.[13] Self-reported weight and height were assessed by asking, "About how much do you weigh without shoes?" and "About how tall are you without shoes?" Diagnosed diabetes was assessed by asking, "Have you ever been told by a doctor that you have diabetes?" The answer was coded yes or no to be similar to our previous reports. Those with gestational diabetes were considered to have diabetes. The type of diabetes was not assessed.

High blood pressure was assessed by asking, "Have you ever been told by a doctor, nurse, or other health professional that you have high blood pressure?" High cholesterol was assessed by asking, "Have you ever been told by a doctor, nurse, or other health professional that your blood cholesterol is high?" Asthma was assessed by asking, "Have you ever been told by a doctor, nurse, or other health professional that you had asthma?" Arthritis was assessed by asking, "Have you ever been told by a doctor that you have arthritis?" Health status was assessed by asking, "Would you say that in general your health is: excellent, very good, good, fair, or poor?"

SAS and SUDAAN statistical software programs were used in the analyses and to account for the complex sampling design.[14,15] We used Proc Logistic in SUDAAN to generate the odds ratios (ORs) and their 95% confidence intervals (CIs) for the association of BMI and medical conditions. Because of the large sample size (195 005 participants), we have not emphasized statistical testing.

RESULTS

The prevalence of obesity among US adults (TABLE 1) increased to 20.9% in 2001 from 19.8% in 2000, an increase of 5.6%. Since 1991 the percentage of those who were obese increased by 74% (1991 prevalence, 12%). That prevalence rate represents an estimated 21.4 million obese men and 22.9 million obese women, for a total of 44.3 million obese US adults. The percentage of adults with a BMI of 40 or higher was 2.3% (1.7% men, 2.8% women) vs 2.1% in 2000 and 0.9% in 1991. Among racial groups, blacks had the highest rate of obesity (31.1%). Among states, Mississippi had the highest rate of obesity (25.9%) and Colorado the lowest (14.4%; TABLE 2, FIGURE, A). Since 1991, the percentage of overweight adult participants increased from 45% to 58%. Of those overweight in 2001, 65.9% were men and 49.9% were women.

The prevalence of those diagnosed with diabetes increased to 7.9% in 2001 from 7.3% in 2000, an increase of 8.2% and an increase of 61% since 1990 (1990 prevalence, 4.9%). Thus, in 2001, an estimated 16.7 million US adults could have been diagnosed as having diabetes (6.9 million men; 9.8 million women). In 2001, 3.4% of US adults (2.9% men, 3.8% women) were both obese and had diabetes, an increase of 1.4% in 1991. Blacks had the highest rate of diagnosed diabetes (11.2%) among all race groups, and adults with less than a high school education had the highest rate (13.0%) among the educational levels. Of US adults aged 60 years or older, 15.1% had diagnosed diabetes. Alabama had the highest rate of diagnosed diabetes (10.5%) and Minnesota the lowest (5.0%; Table 2, Figure, B).

Table 2. Obesity and Diabetes Prevalence Among US Adults by State, Behavioral Risk Factor Surveillance System, 2001*

	Obesity, % (SE)	Diabetes, % (SE)
Total	20.9 (0.16)	7.9 (0.11)
State		
Alabama	23.4 (0.91)	10.5 (0.63)
Alaska	21.0 (1.05)	6.4 (0.70)
Arizona	17.9 (0.98)	8.3 (0.64)
Arkansas	21.7 (0.86)	8.9 (0.59)
California	20.9 (0.79)	8.3 (0.55)
Colorado	14.4 (0.87)	5.6 (0.59)
Connecticut	17.3 (0.54)	7.5 (0.35)
Delaware	20.0 (0.88)	8.2 (0.58)
District of Columbia	19.9 (1.13)	9.1 (0.78)
Florida	18.4 (0.68)	10.3 (0.52)
Georgia	22.1 (0.80)	7.7 (0.45)
Hawaii	17.6 (0.85)	7.2 (0.60)
Idaho	20.0 (0.69)	6.3 (0.40)
Illinois	20.5 (0.74)	8.1 (0.48)
Indiana	24.0 (0.77)	7.1 (0.43)
Iowa	21.8 (0.80)	6.1 (0.42)
Kansas	21.0 (0.70)	6.6 (0.39)
Kentucky	24.2 (0.76)	7.1 (0.37)
Louisiana	23.3 (0.70)	8.5 (0.43)
Maine	19.0 (0.89)	8.0 (0.65)
Maryland	19.8 (0.76)	8.1 (0.55)
Massachusetts	16.1 (0.49)	6.8 (0.33)
Michigan	24.4 (0.81)	7.8 (0.47)
Minnesota	19.2 (0.71)	5.0 (0.37)
Mississippi	25.9 (0.92)	10.3 (0.62)
Missouri	22.5 (0.89)	7.3 (0.53)
Montana	18.2 (0.89)	6.2 (0.52)
Nebraska	20.1 (0.80)	6.4 (0.44)
Nevada	19.1 (1.35)	6.5 (0.71)
New Hampshire	19.0 (0.72)	6.9 (0.42)
New Jersey	19.0 (0.71)	8.4 (0.48)
New Mexico	18.8 (0.80)	7.1 (0.49)
New York	19.7 (0.78)	7.7 (0.51)
North Carolina	22.4 (0.86)	7.6 (0.48)
North Dakota	19.9 (0.89)	5.8 (0.50)
Ohio	21.8 (0.89)	8.0 (0.53)
Oklahoma	22.1 (0.82)	8.4 (0.51)
Oregon	20.7 (0.89)	6.6 (0.54)
Pennsylvania	21.4 (0.78)	7.8 (0.52)
Rhode Island	17.3 (0.75)	7.3 (0.48)
South Carolina	21.7 (0.86)	9.4 (0.57)
South Dakota	20.6 (0.64)	6.8 (0.38)
Tennessee	22.6 (0.92)	8.3 (0.61)
Texas	23.8 (0.64)	8.0 (0.39)
Utah	18.4 (0.85)	5.5 (0.47)
Vermont	17.1 (0.64)	6.1 (0.39)
Virginia	20.0 (0.85)	6.7 (0.50)
Washington	18.9 (0.68)	6.5 (0.41)
West Virginia	24.6 (0.90)	9.3 (0.58)
Wisconsin	21.9 (0.83)	5.8 (0.44)
Wyoming	19.2 (0.81)	5.2 (0.42)

*Data reflect national estimates.

Both overweight and obesity were significantly associated with diabetes, high blood pressure, high cholesterol levels, asthma, arthritis, and fair or poor health status (TABLE 3). Compared with adults with normal weight, those with a BMI of 40 or higher had an OR of 7.37 (95% CI, 6.39-8.50) for diagnosed diabetes, 6.38 (95% CI, 5.67-7.17) for high blood pressure, 1.88 (95% CI, 1.67-2.13) for high

cholesterol levels, 2.72 (95% CI, 2.38-3.12) for asthma, 4.41 (95% CI, 3.91-4.97) for arthritis, and 4.19 (95% CI, 3.68-4.76) for fair or poor health.

COMMENT

Our study, the largest telephone survey of adults in the United States, shows a continuing increase of obesity and diabetes in both sexes, all ages, all races, all educational levels, and all smoking levels. Because of the strong association between overweight and obesity and several well-established risk factors for morbidity and mortality, reversing the obesity epidemic is an urgent priority.

However, these rates are no doubt substantial underestimates. First, individuals without telephones are not included in BRFSS, and such persons are likely to be of low socioeconomic status, a factor associated with both obesity and diabetes.[16,17] Second, in validation studies of self-reported weight and height, overweight participants tend to underestimate their weight, and all participants tend to overestimate their height.[18-20] Recent estimates of obesity among US adults is about 30% based on measured weight and height.[21] Third, undiagnosed diabetes was not counted; recent estimates indicate that about 35% of all persons with diabetes have not been diagnosed.[3]

Both obesity and type 2 diabetes are preventable. Previous studies have demonstrated that changes in lifestyle are effective in preventing both diabetes and obesity in high-risk adults with impaired glucose tolerance.[22,23] Increasing physical activity, improving diet, then sustaining these lifestyle changes can reduce both body weight and risk of diabetes. We found that in 2001, 25.5% of US adults did not engage in any leisure-time physical activity. This is a modest decrease from a 27.0% rate in 2000, but it shows that current physical activity levels are still far below what they need to be.

We previously reported that less than 20% of US adults who were trying to lose or maintain weight were following recommendations to eat fewer calories and increase physical activity to at least 150 minutes per week.[10] Health professionals must continue to stress the importance of a balanced diet and physical activity for healthy weight loss. In US society, men and women must

Figure. Prevalence of Obesity and Diagnosed Diabetes Among US Adults, 1991 and 2001

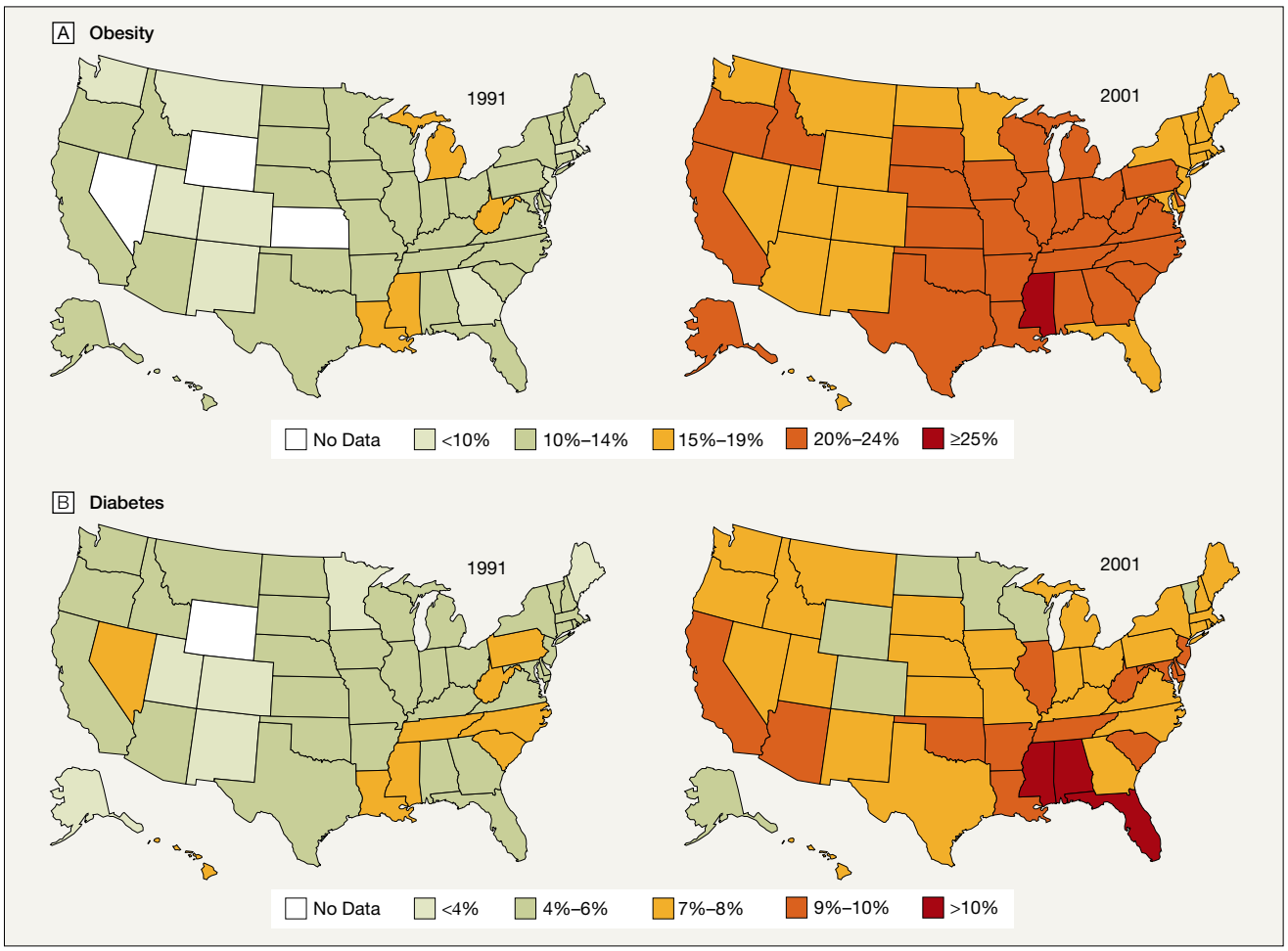

Table 3. Relation Between Body Mass Index and Selected Risk Factors, Behavioral Risk Factor Surveillance System, 2001*

Variable	Total (N = 195 005)	Body Mass Index			
		Normal (n = 84 469)	Overweight (n = 70 231)	Obese, Class 2 (n = 35 767)	Obese, Class 3 (n = 4538)
Diabetes					
Yes, % (SE)	7.9 (0.11)	4.1 (0.12)	7.3 (0.18)	14.9 (0.70)	25.6 (1.16)
Age adjusted		1.00	1.59 (1.47-1.72)	3.66 (3.38-3.96)	8.51 (7.41-9.78)
Fully adjusted		1.00	1.59 (1.46-1.73)	3.44 (3.17-3.74)	7.37 (6.39-8.50)
High blood pressure					
% (SE)	25.7 (0.17)	15.9 (0.21)	27.8 (0.29)	40.9 (0.45)	50.9 (1.32)
Age adjusted		1.00	1.88 (1.79-1.96)	3.72 (3.53-3.93)	7.03 (6.25-7.90)
Fully adjusted		1.00	1.82 (1.74-1.91)	3.50 (3.31-3.70)	6.38 (5.67-7.17)
High cholesterol					
% (SE)	31.0 (0.20)	23.5 (0.29)	34.1 (0.34)	39.4 (0.50)	36.2 (1.34)
Age adjusted		1.00	1.53 (1.46-1.60)	1.93 (1.83-2.04)	1.87 (1.65-2.11)
Fully adjusted		1.00	1.50 (1.43-1.57)	1.91 (1.80-2.01)	1.88 (1.67-2.13)
Asthma					
% (SE)	11.0 (0.12)	9.9 (0.18)	10.0 (0.20)	13.9 (0.31)	22.6 (1.12)
Age adjusted		1.00	1.05 (0.99-1.12)	1.55 (1.45-1.65)	2.77 (2.43-3.16)
Fully adjusted		1.00	1.14 (1.08-1.22)	1.62 (1.52-1.73)	2.72 (2.38-3.12)
Arthritis					
% (SE)	23.0 (0.16)	17.7 (0.21)	23.7 (0.28)	32.1 (0.41)	44.2 (1.31)
Age adjusted		1.00	1.24 (1.18-1.29)	1.92 (1.83-2.03)	4.55 (4.04-5.11)
Fully adjusted		1.00	1.38 (1.31-1.44)	2.03 (1.92-2.14)	4.41 (3.91-4.97)
General health					
% Fair or poor (SE)	15.2 (0.15)	11.8 (0.19)	14.1 (0.23)	22.5 (0.41)	37.6 (1.28)
Age adjusted		1.00	1.10 (1.05-1.17)	2.01 (1.89-2.14)	4.80 (4.27-5.40)
Fully adjusted		1.00	1.06 (1.00-1.12)	1.81 (1.70-1.93)	4.19 (3.68-4.76)

*Full model is adjusted for age, education, smoking, sex, and race or ethnicity.

overcome many obstacles to make the best choices for optimal health.

Although clinical preventive services to identify and control hypertension, elevated cholesterol levels, asthma, arthritis, and diabetes remain important medical priorities nationally, development and implementation of national programs to promote a balanced diet, increase physical activity, and maintain weight control must be national priorities as well.

Author Contributions: *Study concept and design:* Mokdad, Bowman, Dietz, Bales, Marks.
Acquisition of data: Mokdad, Bales.
Analysis and interpretation of data: Mokdad, Ford, Bowman, Dietz, Vinicor.
Drafting of the manuscript: Mokdad, Dietz, Marks.
Critical revision of the manuscript for important intellectual content: Mokdad, Ford, Bowman, Vinicor, Bales, Marks.
Statistical expertise: Mokdad, Ford.
Obtained funding: Mokdad, Bales, Marks.
Administrative, technical, or material support: Mokdad, Bowman, Dietz.
Study supervision: Vinicor, Bales, Marks.
Acknowledgment: We thank the BRFSS state coordinators for their valuable assistance.

REFERENCES

1. Must A, Spadano J, Coakley EH, Field AE, Colditz G, Dietz WH. The disease burden associated with overweight and obesity. *JAMA*. 1999;282:1523-1529.
2. Pi-Sunyer FX. Health implications of obesity. *Am J Clin Nutr*. 1991;53:1595S-1603S.
3. Centers for Disease Control and Prevention. *National Diabetes Fact Sheet: General Information and National Estimates on Diabetes in the United States, 2000*. Atlanta, Ga: US Dept of Health and Human Services, Centers for Disease Control and Prevention; 2002.
4. Ford ES, Williamson DF, Liu S. Weight change and diabetes incidence: findings from a national cohort of US adults. *Am J Epidemiol*. 1997;146:214-222.
5. Resnick HE, Valsania P, Halter JB, Lin X. Relation of weight gain and weight loss on subsequent diabetes risk in overweight adults. *J Epidemiol Community Health*. 2000;54:596-602.
6. Will JC, Williamson DF, Ford ES, Calle EE, Thun MJ. Intentional weight loss and 13-year diabetes incidence in overweight adults. *Am J Public Health*. 2002; 92:1245-1248.
7. Allison DB, Fontaine KR, Manson JE, Stevens J, VanItallie TB. Annual deaths attributable to obesity in the United States. *JAMA*. 1999;282:1530-1538.
8. Colditz G. Economic costs of obesity and inactivity. *Med Sci Sports Exerc*. 1999;31(suppl):S663-S667.
9. American Diabetes Association. Economic consequences of diabetes mellitus in the US in 1997. *Diabetes Care*. 1998;21:296-309.
10. Mokdad AH, Bowman BA, Ford ES, Vinicor F, Marks JS, Koplan JP. The continuing epidemics of obesity and diabetes in the United States. *JAMA*. 2001;286:1195-1200.
11. Nelson DE, Holtzman D, Waller M, Leutzinger CL, Condon K. Objectives and design of the Behavioral Risk Factor Surveillance System. In: Proceedings of the section on survey methods, American Statistical Association National Meeting; August 10; Dallas, Tex, 1998.
12. Remington PL, Smith MY, Williamson DF, Anda RF, Gentry EM, Hogelin CG. Design, characteristics, and usefulness of state-based behavioral risk factor surveillance: 1981-87. *Public Health Rep*. 1988;103:366-375.
13. National Heart, Lung, and Blood Institute. *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report*. Rockville, Md: National Heart, Lung, and Blood Institute; 1998.
14. *SAS System*. Version 8. Cary, NC: SAS Institute Inc; 2001.
15. Shah BV, Barnwell BG, Bieler GS. *SUDAAN User's Manual*. Release 8. Research Triangle Park, NC: Research Triangle Institute; 2000.
16. Ford ES. Characteristics of survey participants with and without a telephone. *J Clin Epidemiol*. 1998;1: 55-60.
17. Harris MI, Flegal KM, Cowie CC, et al. Prevalence of diabetes, impaired fasting glucose, and impaired glucose tolerance in US adults. *Diabetes Care*. 1998;21:518-524.
18. Rowland ML. Self-reported weight and height. *Am J Clin Nutr*. 1990;52:1125-1133.
19. Palta M, Prineas RJ, Berman R, Hannan P. Comparison of self-reported and measured height and weight. *Am J Epidemiol*. 1982;115:223-230.
20. Aday LA. *Designing and Conducting Health Surveys: A Comprehensive Guide*. San Francisco, Calif: Jossey-Bass Publishers; 1989:79-80.
21. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999-2000. *JAMA*. 2002;288:1723-1727.
22. Tuomilehto J, Lindstrom J, Eriksson JG, et al. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *N Engl J Med*. 2001;344:1343-1350.
23. Knowler WC, Barrett-Connor E, Fowler SE, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med*. 2002; 346:393-403.